Space Weather Technical Forecast

Issued on Friday, 24 May 2024 at 13:05 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1 Likely throughout. Slight Chance G1, mainly UTC nights Friday into Saturday, also Sunday into Monday.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate at GOES16, with occasional M-class flares observed. The source region for these has become more diverse relative to earlier in the week, with the largest M2.5 at 23/1320UTC still from AR3679 - as in recent days - but with M-class contributions also seen from AR3689 and now AR3685.

There are now six numbered sunspot regions on the disc, with a unipolar group in the northeast now designated as AR3690. Analysis of AR3679 is now becoming more difficult as it approaches the southwestern limb, however it appears to have shrunk slightly in its central spots, otherwise presenting as a Esc/BGD.

Other spot groups appeared to show little change in visible light, with slow movement in peripheral spots generally the main observation, with the propensity for activity unclear in the small AR3689, a Cro/Beta, but especially in the increasingly active AR3685, an Esi/Beta.

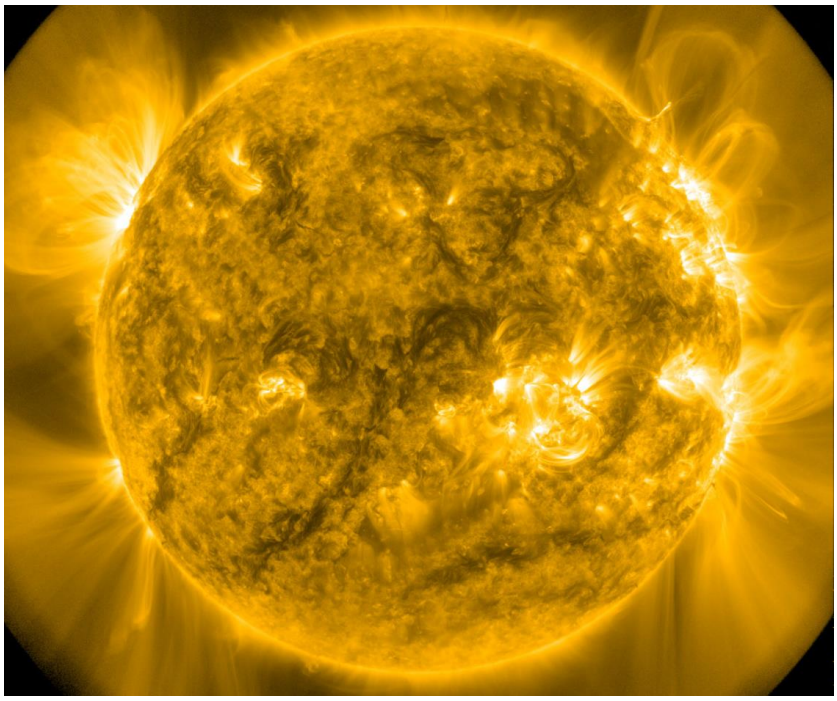

Figure 0: 24/1130UTC SDO AIA171 imagery – a proxy for mangentic field lines emanating from active regions. Note that as well as the offgoing southwest limb activity, there is eveidence on the northeastern limb, perhaps returning Ex-AR3666 and Ex-AR3663.

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There have continued to be numerous Coronal Mass Ejections (CMEs) visible on coronagraph imagery. A re-analysis was undertaken of the filament activity from the southeastern quadrant between 23/0600-0630UTC (i.e. prior to the current reporting period). The latest MOSWOC Enlil run (badge time 24/0600UTC) suggests part of this ejecta is directed south of the ecliptic to no effect, but a second lobe shows a most likely crossing of 1AU as a glance of Earth overnight Sunday 26 in Monday 27 May UTC. CME activity in the current 24-hour period has not yielded further potentially Earth-directed CMEs, however those potentially being produced by AR3685 are awaited in imagery.

At the very end of the reporting period (around 24/1130UTC) an energetic filament eruption was observed from the northwestern limb. Imagery is awaited, although provisionally impacts are not expected from this location.

Solar Wind / Geomagnetic Activity: Solar winds observed by ACE at L1 have been indicative of ongoing slow wind conditions, with Earth probably near the current sheet given the number of solar sector boundary crossings and perhaps also a slight density increase at times.

The solar wind speed was within Background levels in the upper 300s of km/s on a near-level trend. The density was within Background levels in single-figures ppcc, perhaps highest around the middle of the reporting period. The IMF rose slightly from Background to Slightly Elevated levels, peaking at 10nT. The north-south component was mainly anti-aligned with Earth's field and of larger magnitude than any co-alignment, varying from +4 to -9nT. The phi angle started the period mainly positive (away from the Sun), but was mainly negative after 24/0130UTC.

The net result of the above solar wind measures was an overall provisional rise from Quiet to Active, with a peak of Kp 4- in the 21-24UTC interval.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 (greater than 10 MeV) remained at Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was mainly Moderate, with a broad peak of near 500pfu during the UTC afternoon of 23 May. The associated 24-hour fluence has remained below the Active threshold, with an increasing then level trend. Observed fluence at 24/0001UTC was 1.21e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated M-class flares remain possible each day, and a Slight Chance of rising to X. These are most likely from AR3679, but Ex-AR3663 and Ex-AR3666 are also anticipated to return to the northeast limb inside 24 hours' time - with their potency to be confirmed. Ex-AR3664 (the G5-producing group) is then due on Monday 27 May. There is more evidence for AR3664 remaining a potent sunspot group from far-side CME haloes, and risks therefore show a definite uptick on the final day of the period.

Solar Wind / Geomagnetic Activity: Southeast-central filament activity from 0600-0630UTC 23 May has resulted in a possible glance from a CME during the UTC overnight period Sunday 26 into Monday 27 May. Confidence in this is notably low. No other CMEs feature, although note there are unassessed candidates from AR3685.

The coronal hole-based forecast also carries low confidence due its reliance on solar poleward non-persistent features. There is perhaps a Slight Chance of G1 from CH39/- in the next 24 hours, and perhaps a smaller risk again from CH40 at the very end of the four days.

Both the above mechanisms combine to give a Slight Chance of G1 on all days, with the risks highest in the coming UTC night (straddling Friday and Saturday) and again in the UTC night

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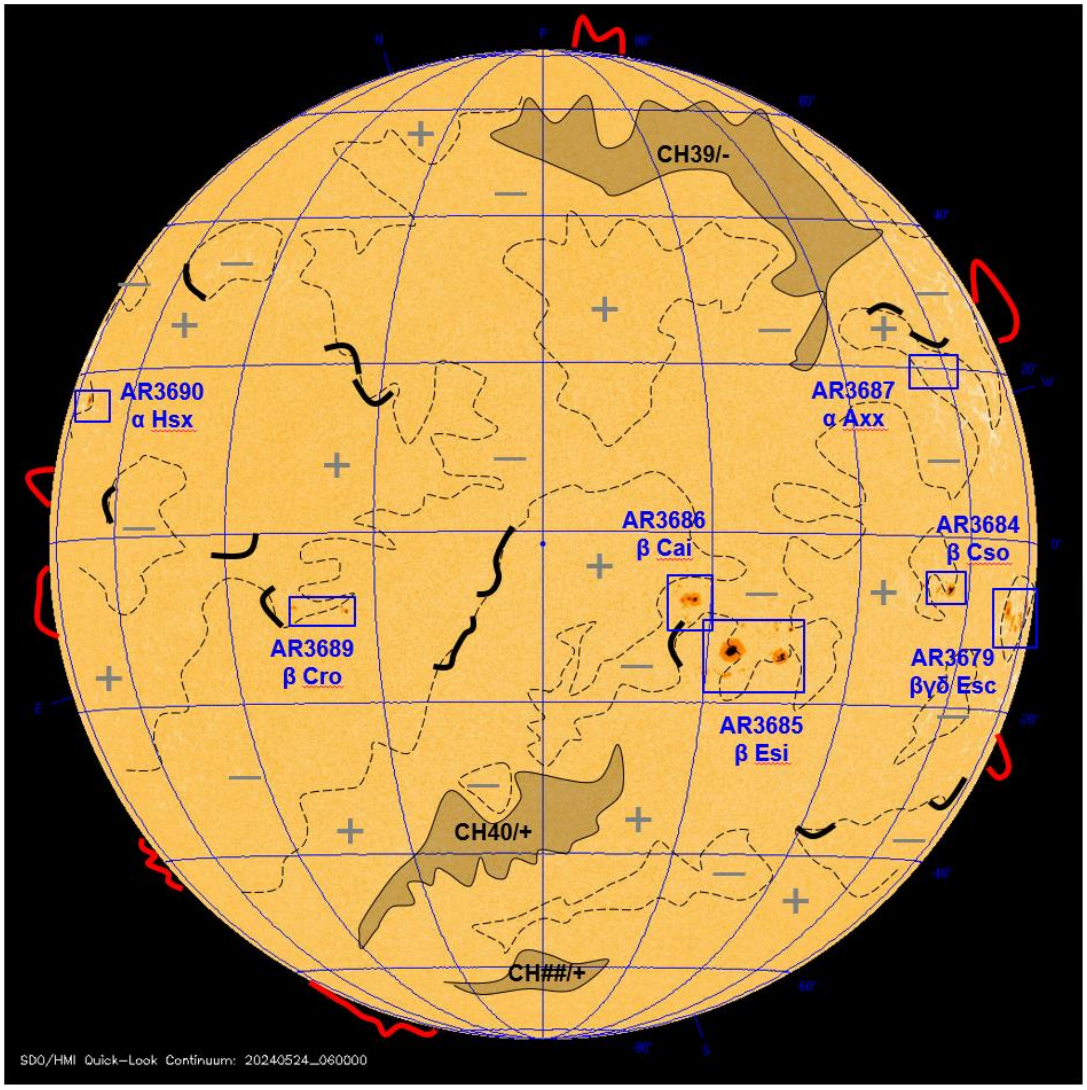
straddling Sunday and Monday - with a respectively mainly 'coronal hole-driven' and then 'CME-driven' rationale.

Energetic Particles / Solar Radiation: High energy proton flux carries a daily Slight Chance of enhancement should any Moderate or Strong flares materialise. The chance of this occurring is expected to gradually reduce late in the forecast period as the larger spot groups reach the far side. Any surviving portion of Ex-AR3664 is likely to be too far east to present any significant risk of S-scale events.

High energy electron flux is forecast to remain at Normal Background to Moderate levels initially, probably attenuating at GEO in any CH39/- fast wind before an uncertain but probably low magnitude recovery into the new UTC week (CME-dependent).

The corresponding fluence is expected to remain below the Active threshold (1e8 integrated flux), but with an eventual (uncertain) rising trend.

Figure 1. Solar Analysis Valid 24/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Southeast-central filament activity from 0600-0630UTC 23 May has been re-analysed. The more notable event was perhaps the disappearing filament observed in H-Alpha around 23/0630UTC, with the position of this near to centre-disc. Coronagraph imagery is heavily polluted for the relevant period by other non-Earth directed CMEs, however there are perhaps faint lobes of ejecta seen heading south and east in the UTC morning of 23 May (between 11 o'clock and 6 o'clock in the plane of Lasco C2). This was modelled in MOSWOC Enlil as two separate events - one heading southward to no modelled Earth effect, but a fainter and more fragmented portion just east of centre disc that intersects the ecliptic plane. This latter portion has resulted in a possible glance from a CME during the UTC overnight period Sunday 26 into Monday 27 May. Confidence in this is notably low - both because of the poor confidence in the fit obtained, but also because MOSWOC Enlil is felt to offer a relatively poor representation of forecast coronal hole fast winds. At the time of writing, no other CMEs feature, although note there are unassessed candidates from AR3685.

The coronal hole-based forecast also carries low confidence due its reliance on solar poleward non-persistent features. There is perhaps a Slight Chance of G1 from CH39/- in the next 24 hours, and perhaps a smaller risk again from CH40 at the very end of the four days, although the 24/0600UTC run of MOSWOC Enlil (and others) entirely disregard the latter.

Both the above mechanisms combine to give a Slight Chance of G1 on all days, with the risks highest in the coming UTC night (straddling Friday and Saturday) and again in the UTC night straddling Sunday and Monday - with a respectively mainly 'coronal hole-driven' and then 'CME-driven' rationale. The fact that the arrivals straddle the 24-hour UTC day risk 'bins' results in an apparently relatively flat forecast risk.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	5	10	10	10
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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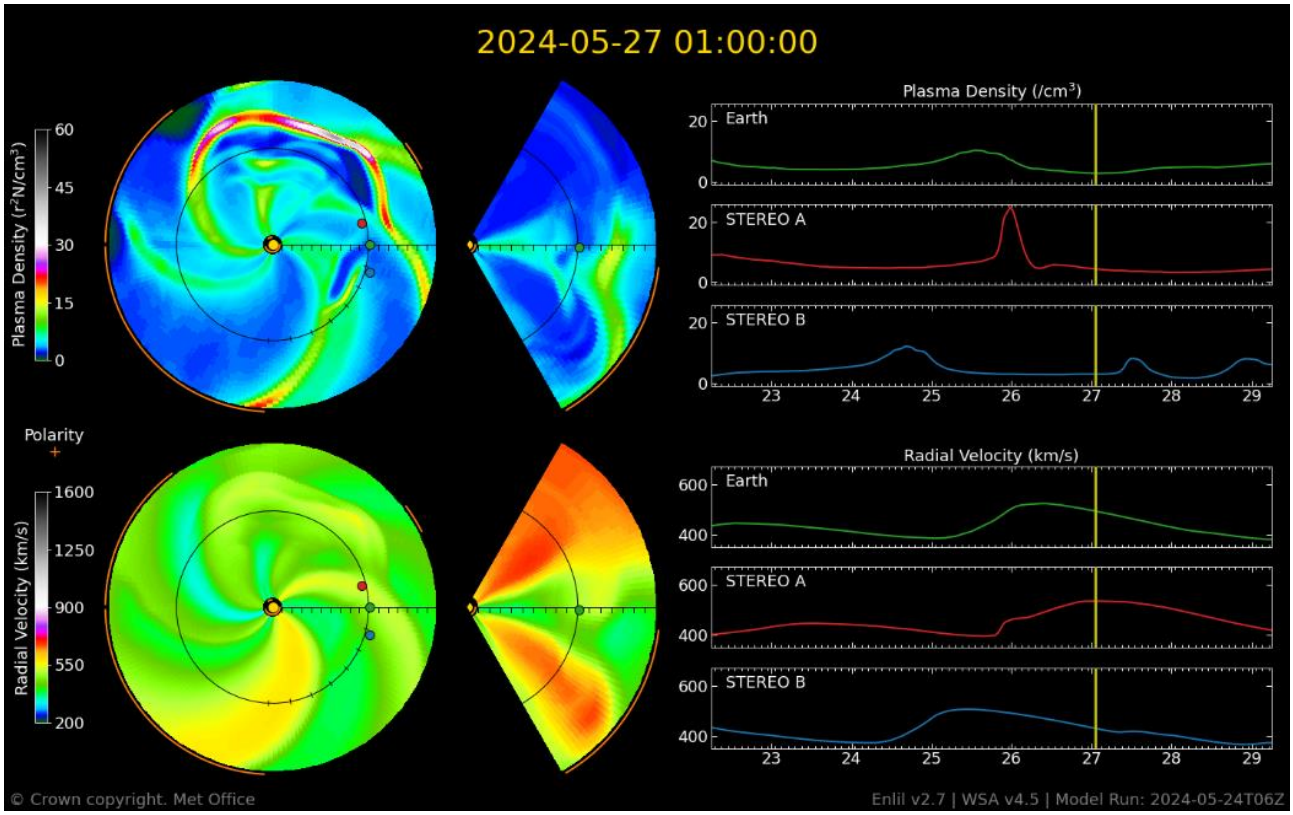
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/1553	Partial?	Filament eruption	SE central	320km/s	UTC night Sunday 26 into Monday 27 May	Notably low confidence (analysis and background model winds). Large error bars, glancing blow.

Figure 2: Latest MOSWOC Enlil run (badge time 24/0600UTC), paused at 1AU crossing time of the 23 May southeast-central filament(s), around the turn of the UTC day 26 into 27 May. This feature can be seen between 0 degrees and 60 East on the density plan view. Enlil's representation of the background solar wind is felt to be low confidence – with only one modelled fast wind (from CH39), later than expected.



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Radio Blackouts - X-Ray Flares:

Ex-AR3663 and Ex-AR3666 may return over the northeastern limb within the next 24 hours - indeed there are signs of EUV flux in AIA171 at the time of writing on the northeastern limb, which may correspond to Ex-AR3666. Perhaps a more assured far-sided survival from recent halo CME evidence is Ex-AR3664, which is the large G5-producing sunspot region of 10-11 May. This is due to return on day four, Monday 27 May, and is the rationale for the uptick in risks at the end of the forecast period.

The majority of recent solar activity has emanated from AR3679, but this is now being eclipsed by AR3685 to its east. This means that any reduction in risk from the departure of AR3679 is now compensated for somewhat by AR3685, which in turn may be bolstered by Ex-AR3664 by the end of the forecast.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	60	60	50	70
Very Active	R3 to R5 X Class	No	5	5	5	10

Figure 3: SDO visualisation from 22 May of near (greyscale) and far-sided potential active regions (yellows), showing a large far-sided northern solar hemisphere return that is likely to correspond to Ex-AR3666 and Ex-AR3663 (dark yellow upper left). Also shown is a large southern solar hemisphere area (lower right), that is likely to be Ex-AR3664. All of these regions should be on the front-side on Monday 27 May, day four of the period.

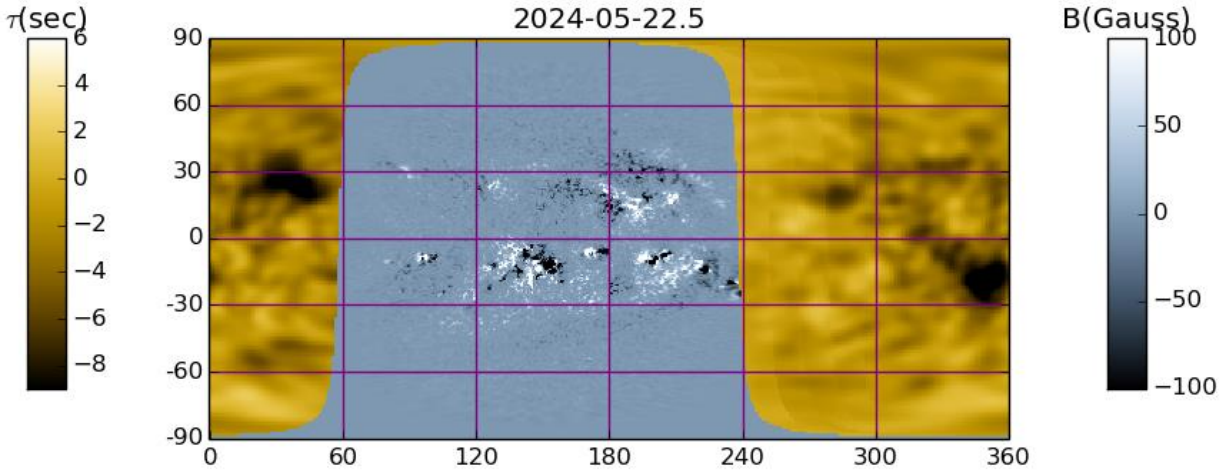

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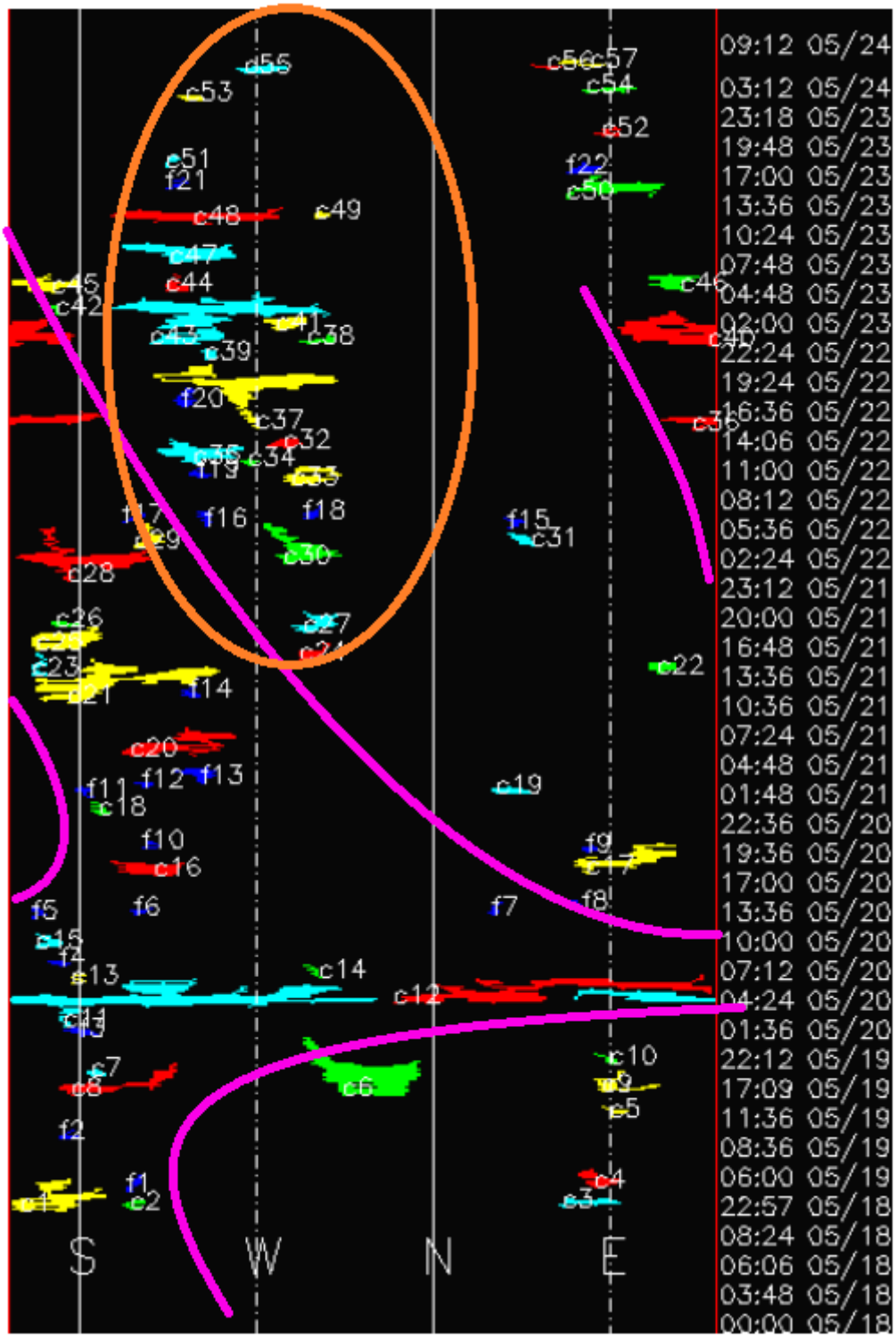
Figure 4: SIDC ROB CACTus CME detections in the past week, showing observed CME headings in the plane of SOHO solar imagery. Individual events have not been assessed, but those inside the hand-drawn magenta polygon (between W, then S then E) could include Ex-AR3664 assuming a slight southerly bias and a brief full-halo potential diametrically opposite Earth. The orange-ringed cluster is largely attributable to the current Earth-facing southwest disc. This diagram also shows the relative lack of northern solar hemisphere CME events.



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux carries a daily Slight Chance of breaching the S1 threshold, largely due to the presence of AR3679, and now perhaps increasingly AR3685, with both approaching the southwest limb.

Because AR3685 is now showing increased activity (if not yet proton enhancements), the peak daily Slight Chance of S1 has been extended in time, but revised downward in magnitude given the lack of recent 10MeV responses at GOES18. The daily risk should eventually decline as AR3679 and then AR3685 rotate onto the far-side, with the returning Ex-AR3664 in a minimally prone position at this time (on the eastern limb), should it even remain active.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The main driver of geomagnetic activity and arising electron response is expected to be the non-persistent CH39/-. Being a new feature, confidence in the ensuing fluence is lower than is typical, and this is now lowered further by the possible influence of the 23 May CME(s) passing 1AU around the time that any upward reaction would otherwise be expected from GOES to the fast wind from CH39.

Overall there is a Slight Chance of eventual Active 24-hour integrated fluence resulting from the fast wind, although the portion of CH39/- near the solar equator appears weak and we are nearing the less potent part of the semi-annual cycle (i.e. we are relatively nearer the muted solstice rather than the equinoxes).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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